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Growth of *Agrotis flammatra* Schiff. (Lepidoptera : Noctuidae) on Lucerne

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The Gram cut-worm, *Agrotis flammatra* Schiff. is a polyphagous insect-pest of economic importance throughout India, as well as, in other parts of the world. It causes damage to cereals, pulses, vegetables, oil seeds and fibre crops, with particular reference to gram, potato, okra, peas, cotton, wheat, tomato, tobacco and other vegetable crops, but the damage is more serious to gram, peas and wheat in Uttar Pradesh. It is also capable of laying large number of eggs. Lefroy (1908), Basu (1944), Srivastava (1959) Thobbi (1961) Ratan Lal and Nayak (1963), Barnes (1965), Bogawat (1967), Kapil (1967), and Chattoraj and Yadav (1968) etc. have worked on the growth of different insects. Srivastava (1959) had worked out the growth potential of *Laphygma exigua* Hb. in relation to the certain winter host plants and he stressed that such type of information is more needed in the case of polyphagous insect-pests as the food plays an important role in the build up of the population.

Present investigations were, therefore, carried out with a view to ascertain the ability of Lucerne crop to support the life of this insect during the months of March and April, 1967 in the laboratory at room temperatures.

Material and Methods

The material and methods as reported in the earlier paper of authors (1968) were followed. The difference being that only leaves of lucerne were provided to insects in these experiments.

In the present series of experiments the larval weights were noted on the completion of the 6 and 12 days after hatching. This was done to find out the growth. Besides average and the range of larval period, percentage of larvae pupated, growth index, mean pupal and larval weight, average pupal period, percentage of adult emergence, the longevity of adults and their size have been noted (Table 1 and 2).

TABLE 1

Duration and weight of larvae and pupae, growth index, percentage emergence and sex-ratio of *Agrotis flammatra* on Lucerne

Replications	No of larvae kept for observation	% of larvae pupated (n)	Range in the larval period in days	Mean larval period (AV)	Growth index (n/AV)	Average pupal duration in days	Mean pupal weight in gm. after 4 days of pupation	Avg. larval wt. in gm.		% of adult emergence	Sex-ratio	
								6th day	12th day		Male	Femals
I	15	53·33	18·23	20·87	2·55	12·66	0·3116	0·016	0·4965	87·5	1 :	2·5
II	15	60·00	21·24	20·00	2·72	12·72	0·2677	0·014	0·4075	66·66	1 :	2
III	15	46·66	19·22	21·14	2·20	12·75	0·3007	0·011	0·412	85·71	1 :	1
Total	45											
Average	15	53·33	21·33	21·33	12·55	2·5	-	0·0136	0·4386	79·75	1 :	1·83

TABLE 2

Size and longevity of adults

Size (cms.) and longevity (days) of male			Size (cms.) and longevity (days) of female		
Body length	Wing expanse	Longevity	Body length	Wing expanse	Longevity
2·00	3·4	7	1·9	3·9	5
1·7	3·2	9	2·00	4·00	8
2·00	4·00	9	1·7	3·2	9
1·9	3·85	7	1·7	3·2	4
1·8	3·00	3	2·2	4·00	7
2·00	3·5	9	1·5	3·5	4
1·9	3·4	6	1·9	3·8	9
			1·7	3·2	10
			1·7	3·2	1
			2·00	3·8	8
			1·9	3·5	7
			2·00	3·6	9
Avg. 1·9	3·478	7·14	1·85	3·575	6·75

Results and Discussion

It is revealed from the above data and the weight gained by the larvae on 6th day varied from 0·011 to 0·016 gm. and an average gain was 0·0136 gm. Similarly on the 12th day they were found in between 0·412 and 0·4965 gm. It is also clear that those larvae which were heavier on the 6th day were found heavier on the 12th day as well. Growth index was found to vary from 2·20 to 2·72.

Percentage of larvae pupated varied from 46·66 to 60 and an average being 53·33. All the larvae completed their development in 18–24 days and the mean range of larval duration was 20·87 to 22 days. Chattoraj and Yadav (1968) have reported that larval period is influenced by the food plants. On comparison to previous findings we have found that caterpillars took approximately equal time to complete their development on wheat and Lucerne. It means they have some common nutritional factors which are responsible for the larval development.

The average pupal weight was noted in between 0·3116 and 0·2677 gm. We found that heavier larvae produced generally heavier pupae and our findings are in agreement with that of Pandey and Srivastava (1967). Basu (1944) and Moussa *et al.* (1960) established a direct relationship between the host plant and pupal period. The present observations however, show that in this case larvae with higher growth index produced pupae having shorter pupal period for *e g.* larvae having mean wt. 0·014 and 0·4075 gm. on 6th and 12th day respectively produced lighter pupae with shorter pupal period. The mean pupal period was found to vary from 12·25 to 12·75 days. Moussa *et al.* (1960) observed a negative relationship between the pupal weight and pupal duration. Pandey and Srivastava (1967) have observed that the pupae with lighter weights normally have shorter period except in few cases in the *Prodenia litura* F. In this case we observed that lighter pupae have shorter period.

Percentage of adult emergence was obtained to vary from 66·66 to 87·5 and mean emergence being 79·75%. Pandy and Srivastava (1967) have observed in *Prodenia litura* that females are produced significantly more except in one case than males. Present studies are also supporting their view, as the females out numbered the males as evident by the sex-ratio (1 : 1·83).

It is clear from the above observations that the size of adult males varied from 1·7 × 3·2 to 2·00 × 4·00 cms. and on an average they attained 1·9 × 3·478 cm. size, while the females were measured in between 1·5 × 3·5 and 2·2 × 4·00 cm. and the mean size calculated comes 1·85 × 3·575 cms. It is evident there fore, that the females were larger than the males. Males lived for 3–9 days and the average life span was 7·14 days. On the other hand females survived for 1–10 days. Their mean longevity was obtained 6·75 days. The females were short lived, while Pandey *et al.* (1968) working on *Diacricia obliqua* found that females lived slightly longer than males in most cases.

Summary

Growth of *Agrotis flammatra* was studied on the Lucerne during the March and April, 1967. Larvae obtained 0·0136 and 0·4386 gm. average weight on 6th and 12th day after hatching respectively. It was found that those larvae were heavier on the 6th day, maintained their weight on 12th day too. Percentage of larval survival varied from 46·66 to 60. The larval period lasted in 18–24 days. Pupal stage was completed in 12·25 to 12·75 days. Heavier larvae produced heavier pupae except in few cases. Pupae obtained mean weight in between 0·2677 and 0·3116 gm. after 4 days of pupation. It was found that lighter pupae have shorter pupal life. Average percentage of adult emergence was noted (79·75%). Females were produced in greater numbers than the males (1 : 1·83). Females were little larger than males and were short lived.

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Influence of Rainfall on the yield of Sugarcane at Shahjahanpur, Uttar Pradesh

By

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Out of the various components of climatic complex influencing the yield of sugarcane, rainfall has been claimed to be the one, and byfar the most important. In insular tropical region such as Java, where monsoons consist of alternating dry and wet seasons, the latter lasting from October to April, Tengwall and Van Der Zijl (1924) observed a high positive correlation between sugar yield and rainfall of October–November. While the rains start in September–October, growth rate is hardly influenced but it is checked considerably when rains are delayed till November or December.

In Formosa, where sugarcane is planted during summer months, Sun and Chow (1947) claimed that any additional rainfall of 10 mm per month above the average during the early months of growth period (September to January) is more or less harmful. It is beneficial during the latter months of growth (February to June) and again harmful after July.

In India, Khanna and Sehgal (1957) failed to find significant relationship between sugarcane yield and the rainfall of different months. They, therefore, observed that total rainfall recorded in a month can not by itself explain the variations of sugarcane yield. According to them, an additional inch of rainfall beyond normal during January, May and June was beneficial while that of February, March, April, August and September was harmful. Acharya *et al.* (1960) did not find well marked effect of rainfall on sugarcane yield. But they claimed that 35·31% of yield variation was attributable to it. The response curve representing the expected change in yield due to additional inch of rain showed that the rain of planting time (January to February) caused harmful effect on yield. Additional rain of summer months of March to June proved beneficial, while that of July to part of August was again harmful. Gangopadhyaya and Sarkar (1963) observed that more rainfall during germination of wheat suppressed it at Adhartal but improved it at Shankarnagar, Jullundur and Gurdaspur. More rainy days of tillering phase caused adverse effect on tiller production at these places.

In Uttar Pradesh, the largest sugarcane growing state of the Indian Union, where this crop covers more than 30 lakh acres of land and produces over 28 lakh tons of raw sugar annually, no attempt had ever been made to analyse the sugarcane yield in relation to rainfall. To fill in this void, present studies were made at Sugarcane Research Station, Shahjahanpur.

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Meterial and Method

Location : Shahjahanpur is situated in the Central Sugarcane growing tract of Uttar Pradesh, at 27°54′ N latitude, 79°56′ E longitude at an altitude of 154·53 metres above the sea level. The tropic of Cancer passes 4° 24′ south of Shahjahanpur at a distance of about 486 kilometres.

Climate : The climate of Shahjahanpur is typical of the subtropical belt. The maximum temperature, minimum temperature, relative humidity, rainfall, rainy days and sunshine range between 22·3°C to 40·4°C, 6·8°C to 26·6°C, 40% to 83%, 3·0 mm to 308·0 mm, 1 day to 17 days and 186·2 hours to 330·4 hours respectively in the different months of the year. In general, maximum and minimum temperatures remain at their lowest ebb during the month of January, increase gradually in the succeeding months and reach at their peaks during the months of May and June respectively, and afterwards decline gradually till January. The relative humidity remains at its lowest during the month of May, increases afterwards till the maximum is reached in the month of August and declines in the succeeding months till May. The rainfall and rainy days remain at their minimum level in the month of April, increase in the succeeding months till August, when maximum is reached and decline afterwards till December. During January to March, an increase is again witnessed and about 60 mm rain is received in 6 rainy days. The duration of solar radiation shows a minimum during July–August, increases afterwards till November, declines during December and again increases in the succeeding months till maximum is reached in the month of May (Table I).

Crop life-cycle : The sugarcane crop is planted between the middle of February to middle of April. The germination is completed by the third week of May, and the young plants face the severe summer drought. The tillering takes place between April to third week of July. Elongation growth starts from the third week of June and goes on till October, after which it almost ceases due to low temperature. The sugar accumulation takes place between October to January onwards.

Average yield and rainfall distribution : The average yield of sugarcane for the years 1947–48 to 1965–66 of Sugarcane Research Station, Shahjahanpur, as well as, the distribution of rainfall during the different epochs of the crops' life cycle was collected (Table II). Although, there had been some changes in the varieties grown on the farm, but cultural and manurial practices had been almost similar. Since a large number of varieties, with varying yield potentiality are grown at the farm annually, the change in their composition was not considered to cause material change in the average yield of the entire farm.

To determine the relation between sugarcane yield and rainfall, correlation coefficient was worked out for yield and total rainfall of the entire cropping season. As, a significant positive correlation was obtained between these, interest arose for determining the relationship between the rainfall of individual epochs and the sugarcane yield, so that the exact period of which, the rain exercised the maximum effect may be known. Therefore, the yield was correlated with the rainfall of different epochs individually, and it was found that the rainfall of elongation phase was most important, as it showed very high positive correlation with yield. Since, the elongation phase covered a period of about 4 months, rainfall distribution of individual fortnights of this period was further worked out and correlated with the yield to make precise estimation of the influence of rainfall of different fortnights on yield. In order to estimate the extent of variation in yield and rainfall of different years, coefficient of variation was also worked out.

TABLE I

Data on weather elements of different months

(Average for 10 years)

S. N.	Months	Max. temp. °C	Min. temp. °C	Humidity %	Rainfall mm.	Rainfall Days	Solar radiation (hrs)
1	January	22·3	6·8	77	25·4	2	261
2	February	25·4	9·0	70	9·6	2	266
3	March	31·3	13·7	60	21·8	2	277
4	April	37·2	19·9	42	3·0	1	298
5	May	40·4	23·6	40	7·8	1	330
6	June	39·0	26·6	56	80·6	5	249
7	July	34·1	25·9	79	251·9	14	186
8	August	32·4	25·6	83	308·0	17	187
9	September	32·7	24·1	81	189·6	10	215
10	October	31·8	18·6	80	134·3	3	282
11	November	28·5	11·3	74	5·0	1	286
12	December	23·6	7·1	74	4·8	1	258

TABLE II

Data of sugarcane yield and rainfall distribution

S. N.	Year	Yield M.T./ha	Rainfall (mm) Planting	Germination	Tillering	Elongation	Ripening	Total
1	1947	40·6	22·1	20·6	109·5	790·4	36·9	841·0
2	1948	46·6	19·0	0·0	194·1	991·9	65·8	1036·6
3	1949	46·4	0·5	4·4	284·1	1192·3	37·1	1258·2
4	1950	46·6	8·4	11·2	247·3	880·9	58·2	952·5
5	1951	46·1	29·7	31·0	95·7	662·8	28·2	794·2
6	1952	47·0	50·8	7·6	340·3	771·7	19·6	859·2
7	1953	52·3	1·0	6·6	520·8	954 0	80·0	1095·5
8	1954	53·6	52·0	1·5	348·2	655·0	101·9	1023·3
9	1955	55·5	0·0	0·8	734·9	1290 3	167·1	1360·3
10	1956	55·7	21·6	56·4	337·9	1073·3	316·7	1254·0
11	1957	48·8	37·4	5·4	221·6	748·8	47·8	946·2
12	1958	49·7	8·6	0·0	155·3	1373·5	352·6	1392·6
13	1959	43·2	16·5	17·8	76·2	530·7	54·2	662·7
14	1960	41·8	113·4	0·8	924·1	1718·8	496·3	1968·1
15	1961	46·1	0·0	0·0	191·2	1409·8	409·8	1544·9
16	1962	40·4	20·9	6·1	177·5	630·8	33·8	782·6
17	1963	44·8	29·5	0·1	230·6	837·4	16·2	987·7
18	1964	37·7	0·5	24·1	273·9	777·8	25·2	818·7
19	1965	30·0	31·7	28·7	127·7	533·1	40·9	576·2
	C.V.	13·4	107·7	117·5	72·4	33·9	112·8	31·9

Results and Discussion

1. *Sugarcane yield, total rainfall, and their relationship.*

Table II reveals that during the 19 years period, cane yield fluctuated between 30·0 to 55·7 M.T./ha and total rainfall varied between 576·2 mm to 1968·1 mm. The coefficient of variation in their cases was found to be 13·4% and 31·9% respectively. It gave an indication that the yield had relatively narrow variation than the rainfall of the entire cropping season, and it was not influenced by the fluctuation of rainfall to similar degree. However, increase in the rainfall was observed to be associated with enhancement in the yield and a significant positive correlation existed between these. The coefficient of correlation came out to be + 0 699. The value of " t " for the observed correlation was 4·01 as against 2·10 and 2·89 expected at 5% and 1% probability levels respectively.

The highly significant positive correlation leads to the conclusion that the yield was influenced favourably with the total rainfall. This finding is contrary to the observations of Acharya *et al.* (1960) but it is in confirmity to the results obtained by Tengwall and Van Der Zijl (1924).

2. *Relation between sugarcane yield and rainfall distribution during different epochs of crop' life cycle.*

The estimates of correlation coefficients between yield and rainfall of different epochs are furnished in table III.

TABLE III

Correlation coefficients for yield and rainfall of individual epochs of sugarcane

S. N.	Epochs	Period	Value of r
1	Planting	Mid February to Mid April	– 0·149
2	Germination	Mid March to third week of May	– 0·105
3	Tillering	First week of April to third week of July.	+ 0·420
4	Elongation	Fourth week of June to third week of October.	+ 0·505***
5	Ripening	First week of October to third week of January.	+ 0·238

*** Very highly significant.

It may be observed from the above table that the yield showed significant correlation with the rainfall of elongation phase alone. As the correlation was positive, it indicated that the rainfall of this period exercised profound beneficial effect on sugarcane yield, which increased with increase in the rainfall. The natural precipitation of other epochs did not show any marked effect on yield. The claims of Acharya *et al.* (1960) that more rainfall of planting time and germination phase caused harmful effect could not be substantiated, as coefficients of correlation were nonsignificant.

3. *Relation between sugarcane yield and rainfall of different fortnights of elongation phase.*

The correlation coefficients for yield and rainfall of different fortnights of the elongation phase of sugarcane are presented in table IV.

TABLE IV

Correlation coefficients for yield and rainfall of individual fortnights of the elongation period

S. N.	Fortnights	Period	Value of r
1	First	Fourth week of June to first week of July	+0·308
2	Second	Second and third weeks of July	+0·071
3	Third	Fourth week of July to first week of August.	+0·096
4	Fourth	Second and third weeks of August	+0·555*
5	Fifth	Fourth week of August to first week of September.	+0·010
6	Sixth	Second and third weeks of September	– 0·621**
7	Seventh	Fourth week of September to first week of October.	+2·273
8	Eighth	Second and third weeks of October	+0·120

*Significant at 5% probability level.
**Significant at 1% probability level.

It may be seen from the above table that out of the 8 fortnights of the elongation phase, only fourth and sixth fortnights showed significant correlation and ondicated the importance of the rainfall of these periods in influencing the yield sif sugarcane. While the rainfall of the fourth fortnight of the elongation phase ahowed a significant positive correlation with yield, that of the sixth fortnight ;stonishingly exhibited negative correlation. It gave an indication that increase in the magnitude of rainfall during the fourth fortnight of elongation phase caused beneficial effect and enhanced the yield of sugarcane. But the higher rainfall of the sixth fortnight of the elongation period caused harmful effect and reduced the yield. Besides the sixth fortnight, all other fortnights showed positive correlation and indicated the beneficial effect of rainfall of these fortnights on yield.

Although the real cause for harmful effect of rainfall of the sixth fortnight of elongation period is not known but it may possibly be due to lodging of the crop caused by rainfall and high winds of this, as well as, of the succeeding fortnight in which the "*Hast*" *Nakshtra* usually occures that had the characteristic feature of rainfall associated with high wind velocity.

Summary and Conclusions

With a view to determining the influence of rainfall, and its distribution during different epochs of the life cycle of sugarcane crop on yield, data for 19 years of Sugarcane Research Station, Shahjahanpur, Uttar Pradesh were examined and analysed statistically. The results revealed that :

1. The sugarcane yield was influenced significantly with the total rainfall obtained during the crop season.

2. The total rainfall had positive relationship with the sugarcane yield. Therefore, an increase in the rainfall caused improvement in sugarcane yield.

3. The yield of sugarcane varied by about 86% due to variation in the rainfall.

4. The higher rainfall of the tillering, elongation and ripening periods proved beneficial for the crop yield in general, but it was significantly enhanced by enhancement in the rainfall of the elongation phase alone, which covered the period extending from the fourth week of June to third week of October.

5. The distribution of the rainfall during different fortnights of the elongation phase also exhibited wide variation in respect to its effect on the yield of sugarcane. While the higher rainfall of first to fifth and seventh to eighth fortnights caused favourable effect on yield, that of sixth fortnight exercised adverse influence on it.

6. Even, amongst the rainfall of different fortnights of the elongation phase, which exercised favourable influence on yield, marked variation was observed in the magnitude of their effect. Amongst these, rainfall of the fourth fortnight (Second and third weeks of August) showed the maximum and that of fifth (Fourth week of August to first week of September) fortnight the minimum favourable effect on yield.

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Studies on the Flea-beetle, *Chaetocnema basalis* Baley (Coleoptera : Chrysomellidae) a pest of wheat in Rajasthan

Part I. Head, Mouth parts and the process of feeding

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The flea-beetle, *Chaetocnema basalis* Baley, was reported as a minor pest of rice in India by Lefroy (1907). Ayyar (1940) mentioned that a number of flea-beetles of the genus *Chaetocnema* act as pest on different vegetables and millet and occasionally cause appreciable losses. Lately *Chaetocnema basalis* has been found to attack wheat seedlings in different parts of Rajasthan. It inflicits heavy damage to a large acreage of wheat fields of this State. Evidently this has necessitated a study of the various aspects of this pest, which have so far been not looked into. The present paper, deals with the morphology and musculature of the head and mouth parts of this insect and their possible functional correlation with a process of feeding.

Head Capsule

The head capsule (Plate I : Fig. 1) is round and shining black in colour. The frontal region of the head is impunctate and finely granulose. The sclerites of the head are fused so compactly that most of the sutures have been obliterated. Compound eyes are present on the dorso-lateral wall of the cranium. Ocelli are absent. The epicranial suture is represented by a short coronal and faintly developed frontal sutures. Two small post frontal sutures are also situated above the latter. A faint fronto-clypeal (epistomal) suture demarcates the clypeus from the frons. The clypeus is separated from the labrum by a clypeo-labral suture. The labrum is attached with the clypeus. It is covered with a number of setae. The genae are narrow and lie below the compound eyes. The frons is represented as a broad region situated in between the frontal sutures. The vertex which forms the top of the head is a large round area ; it lies above the eyes. On the caudal aspects of the head capsule (Fig. 2) is the gula which forms the middle portion of the floor of the head. The gular region is clearly marked off from the gena by means of a distinct gular suture. Just above the gula is the occipital foramen.

Appendages of the Head

Antennae

Each antenna (Plate I : Fig. 4) is filiform and made of eleven segments. The base of the antenna is lodged in the antennal socket. The antennae are covered throughout with minute hair.

ABBREVIATIONS

AD—Antennal adductor muscle ; ABD—Antennal adductor muscle ; AEXT—Antennal extensor muscle ; AFLX—Antennal flexor muscle ; AS—Antennal suture ; AST—Antennal socket ; CD—Condyle ; CL—Clypeus ; CLS—Clypeolabral suture ; CMP—Compressor muscle ; CR—Rod ; CRD—Cardo ; DFLX—Dorsal flexor ; EPX—Epipharynx ; F—Frons ; FCS—Froto-clypeal suture ; or epistomal suture ; FLXL—Flexor of lacinia ; GL—Gula ; GS—Gular suture ; GLA—Galea ; HRM—Hypopharyngeal retractor ; HYPX—Hypopharynx ; LC—Lacinia ; LG—Ligula ; LB—Labial palp ; LBS—Labial suture ; LAE—Labila adductor externus ; LAI—Labial adductor internus ; MAD—Mandibular adductor ; MBD—Mandibular abductor ; MD—Mandible ; MXP—Maxillary palp ; OF—Occipital foramen ; P-Pedicel ; PFS—Post frontal suture ; PLG—Palpifer ; POS—Post occipital suture ; PT—Posterior tentorial pit ; PG—Post gena ; SC—Scape ; SM—Submentum ; TS—Stipes ; TR—Tormae ; TM—Tormal muscle ; T—Teeth ; V—Vertex ; VFLX—Ventral flexor.

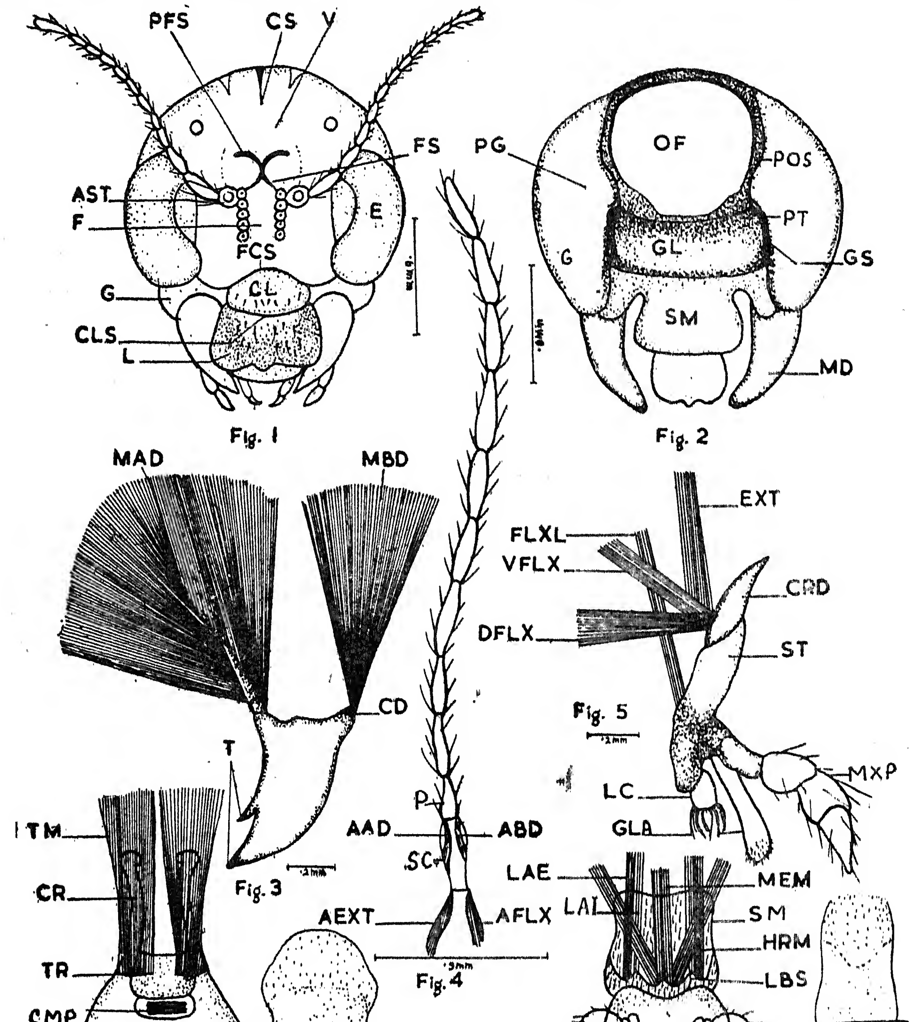

PLATE I

Fig. 1. Dorsal view of the head.
Fig. 2. Ventral view of the head.
Fig. 3. The mandible.
Fig. 4. The antenna.
Fig. 5. The maxilla.
Fig. 6A. The labrum.
Fig. 6B. The epipharynx.
Fig. 7A. The labium.
Fig. 7B. The hypopharynx.

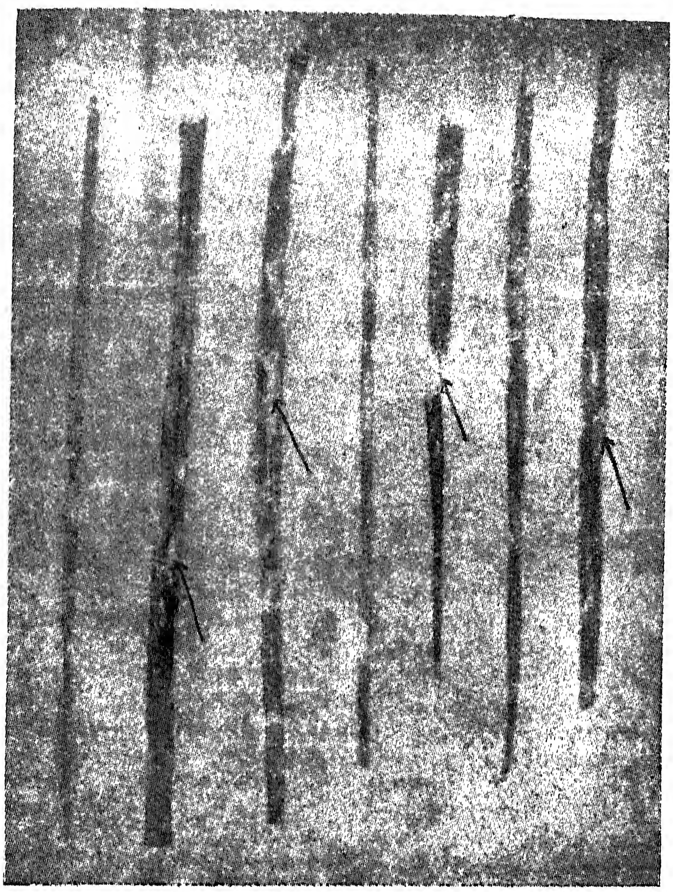

PLATE 2.

Photograph of the damaged leaves of wheat showing the nature of injury.

Musculature : There are two extrinsic muscles, the antennal flexor and the antennal extensor which arise from the frons and insert on the inner surface of the scape. Within the scape two intrinsic muscles, the adductor and the abductor are present. The former arises from the outer ridge of the proximal end of the scape and is inserted on the base of the pedicel, while the latter originates from the inner side of the proximal end of the scape and inserts on the pedicel.

Labrum

The labrum (Plate 1 : Fig. 6) is broader than long. It is movably articulated with the clypeus. The epipharynx (Fig. 6B) is a simple membranous structure. A pair of small sclerites, the tormae, are present on the posterio–lateral sides of the labrum. From each torma a chitinous rod arises which projects into the epipharyngeal region.

Musculature : A pair of extrinsic muscles, arising from the inner surface of the frons and inserting on the tormae, are present. Besides this a strong unpaired compressor muscle, joining the dorsal and ventral surfaces of the labrum is also present.

Mandible

The mandibles (Plate 1 : Fig. 3) are strongly sclerotised. Each mandible bears two pointed teeth at its distal end. There are no molar teeth.

Musculature : A large and powerful adductor muscle arises from the inner surface of the roof of the head and inserts through a plate like tendon on the inner angle of mandibular base. The abductor muscle originates from the lateral side of the epicranium and inserts on the outer angle of the base of the mandible by means of a tendinous cord.

Maxilla

The cardo (Plate 1 : Fig. 5) is more or less a triangular sclerite. The stipes is broad and bears terminally the galea and lacinia. The galea bears a tuft of hairs where as lacinia is covered with pointed bristles at its tip. The maxillary palpus is a four segmented appendage which is clothed by a number of hairs.

Musculature : Each maxilla is provided with four extrinsic muscles. The ventral flexor arises from the anterior gular margin and inserts on the base of the cardo. The dorsal flexor also arises from the anterior gular margin and inserts on the base of the cardo adjacent to the region of the insertion of the ventral flexor muscle. The extensor muscle originates from the posterior epicranial region and inserts on the cardo near the insertion of the region of the ventral flexor. The flexor of lacinia is a long muscle ; it arises from the posterior gular margin and inserts on the base of lacinia.

Labium

The submentum (Plate 1 : Fig. 7) is attached with the entire width of the gula. It is separated from the mentum by a district line which has been termed as labial suture by Imms (1957). The submentum possesses backwardly directed hair on its internal surface. There is no distinct demarcation between mentum and prementum. The ligula is a broad structure which has been formed by the fusion of glossae and paraglossae. Its free outer border is raised upwards and also bent slightly backwards. The hypopharynx is membranous and remains adnate on the dorsal surface of the labium.

Musculature : There are two labial adductor muscles on each side. They arise from the posterior gular margin and insert on the prementum. A pair of median flexor muscles, which arises from the posterior margin of the submentum, is also present. There is a pair of hypopharyngeal muscles (retractors) which arise from the anterior gular margin and after running along the inner margin of the hypopharynx insert on its proximal border ; the two muscles remain closely attached at the region of their insertion on the hypopharynx.

Feeding Mechanism

These beetles generally feed in the early hours of night since during day time they remain hidden within the axils of the leaves or under some cover in the soil around the stem.

The feeding mechanism does not conform to the generalised pattern of other phytophagous Coleoptera. They simply scrape the green tissues from the leaves; this function is evidently accomplished by the mandibles which possess only the incisor teeth, the molars being absent.

The maxilla does not show any special feature which might have developed in response to the feeding habit of this insect. However, presence of an unusually large number of bristles and hairs on the lacinia and galea appears to help in holding the scraped parts of the leaf and diverting them towards the mouth.

The labium has a well developed mentum and ligula. The raised outer border of the latter does not allow the scraped part of the leaf to escape. Moreover, on account of the smooth surface of the mentum, the food slips towards the sub-mentum. The hairs on the sub-mentum, which are mostly directed towards the oesophagus, help the insect in two ways: firstly they provide a smooth passage to the food into the oesophagus and secondly they do not allow it to escape in the reverse direction.

The nature of injury caused by beetles is visible externally in the form of large irregular patches on the leaf. Very seldom the edges of the leaf are damaged. When the attack is serious it has been observed that practically every leaf blade possesses several large and small patches which turn white or pale white due to the loss of their green tissue. This lowers the vitality of the plants to develope and grow.

Discussion

The demarcation of the dorsal limits of the clypeus has been a disputable question in some members of the family Chrysomellidae. Khatib (1946) recognised the presence of anteclypeus and post-clypeus in *Galerucella birmanica* but did not make any mention of the epistomal suture. However, in *Chaetocnema basalis* an epistomal suture with a fairly developed internal ridge is present and the clypeus is distinctly demarcated. The coronal and frontal sutures are quite conspicuous in *Chaetocnema basalis* but the two small lines above the frontal suture require interpretation. In view of their position, they have been called post-frontal sutures in the present text, but this is contrary to the generalised condition mentioned by Snodgrass (1935) that the frontal and post-frontal sutures do not occur in the same species. Harwalkar and Ali (1962), ignoring the above generalisation, termed a pair of sutures present on the dorsal side of the frontal sutures in *Rhaphidopalpa favoecollis* as post-frontals. Earlier, Crampton (1932) had established the presence of post-frontals and their independence from frontal sutures. Hence the presence of both the post-frontals and frontals in *Chaetocnema* is not very unusual.

In respect to the gnathal musculture, it is noted that while the labral muscles are generally similar to those of *Tenebrio* (Dass, 1937); *Coccinella* (Pradhan, 1938); *Mylabris* (Sexena, 1953); and *Aulacophora* (Saini, 1958), difference has been observed to the effect there is only one compressor muscle instead of two in *Chaetocnema*. The absence of molar teeth on the mandible, an important character an this insect, evidently is correlated with its feeding habit of scraping the leaf tissues. The musculature of mandible, however, is on the generalised pterygote pattern (Snodgrass, 1935) and closely resembles that of *A. foevicollis* (Saini, 1958). The occurrance of extrisinc muscles with the maxilla also conforms to that of the maxilla of *Aulacophora* (Saini, 1958). However, the ventral flexor and the flexor of

lacinia arise from the gular margins instead of from the tentorium because the latter is very poorly developed in *Chaetocnema basalis*, a condition similar to that of *Dytiscus* (Bauer, 1910) and *Aulacophora* (Saini, 1958). The two extrinsic muscles of labium *i.e.* labial adductors also arise from the gular margin ; otherwise these present a typical mandibulate disposition.

Summary

The morphology and musculature of the head and mouth parts of *Chaetocnema basalis* Baley, and its feeding mechanism have been described.

Acknowledgement

We are thankful to Dr. B. K. Srivastava, Director of Research for providing necessary laboratory facilities in conducting this work.

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Fungal Protein Production by *Rhizoctonia solani* when grown on Cellulose as the sole source of Organic carbon

By

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Introduction

At present at least half of the population of India gets poorly balanced diet (Sukhatme 1965). Continued consumption of low protein foods or other foods lacking certain essential amino acids leads to the development of a disease known as *Kwashiorkor*, a Ghanaian name.

Gray and other associates (1966-67) presented evidence that cheap carbohydrates such as sweet potatoes, manioc, sugar beet, rice, and sugarcane juice could be used as substrate for their conversion into fungal protein to alleviate the present world protein shortage. Keeping in view the shortage of such carbohydrates in India, Chahal and Gray (1969*a* and 1969*b*) turned to the utilisation of cellulosic material, the cheapest source of organic C, for fungal protein production. They reported that out of 44 different cellulolytic fungi only four viz. *Myrothecium verrucaria*, *Chaetomium globosum*, *Rhizoctonia solani* and *Trichoderma* sp. were able to grow well on wood pulp and produced maximum amount of fungal protein. *R. solani* was taken up for further experimentation as it gave highest percentage and total protein production as compared to the other three test fungi.

Material and Methods

Methods for maintenance of fungi, preparation of inocula, estimation of growth in respect of protein production and the composition of the basal synthetic medium used were same as described earlier by Chahal and Gray (1969*a*). Cellulose was used in the form of wood pulp prepared by Sulphate Process from wood of mixed conifers. Wood pulp was supplied by M/s Shree Gopal Mills Ltd., Yamunanagar, Ambala (Haryana).

The qualitative analysis of amino acids were done by Thin Layer Chromatography (T.L.C.). The combination of solvants used were same as given by Brenner and Niederwieser (1960). The mixture of *n*-butanol, glacial acetic acid and water (4:1:1) was used for first dimensional run and mixture of phenol and water (3:1) for the second dimensional run. Presence of essential amino acids were determined by comparing Rf values of amino acids in known mixture when run parallel to the test extracts from various samples.

Results

(i) Comparison of different isolates in respect of protein production :

Various isolates showed marked differences in their growth behaviour when grown on basal synthetic medium with glucose as C source. Thus it was considered worthwhile to screen these isolates for their ability to convert wood pulp

into fungal protein. Potassium nitrate at the rate of 400 mg N per litre was used in basal medium.

The results presented in Table 1 indicate that these isolates differed in respect to total protein production with one another to a great extent. The isolate No. 1 gave the highest protein percentage, followed by isolate No. 2, 3, 4 and 5.

TABLE 1

Comparison of 10 isolates of R. solani in respect of Protein Production

Isolate No.	Source of isolate	Final pH	Wt. of mycelium and undigested wood pulp in mgs after 4 day	Percentage of protein	Total protein per flask in mgs
1.	Turnip Root (*Brassica compestris* var. *rapa* L.)	7·0	399	18·44	73·75
2.	Rotten Hessian cloth	7·2	519	13·78	71·00
3.	Methi roots (*Trigonella foenum-graecum* L.)	6·3	482	13·37	64·44
4.	Groundnut roots (*Arachis hypogaea* L.)	6·9	532	13·21	70·25
5.	Soil	7·0	539	12·50	67·37
6.	Dead insect (*Circulifer naushrensis*)	6·8	609	10·49	63·88
7.	Wheat roots (*Triticum aestivum* L.)	6·7	652	9·62	62·72
8.	Groundnut roots	6·6	686	8·56	58·75
9.	Groundnut seeds	6·7	703	5·69	40·00
10.	Mung roots (*Phaseolus aureus* Roxb.)	6·4	748	3·61	27·00

TABLE 2

Comparsion of amino acid contents of 4 different isolates of R. solani

No. of isolate	Source of isolate	Arginine	Histidine	Phenylalanine	Methionine	Leucine and or isoleucine	Valine	Lysine	Threonine	Tryptophan	Total No. of amino acids
1.	Turnip roots	+	+	+	+	+	+	+	+	+	21
2.	Rotten Hessian cloth	+	+	+	+	+	+	+	–	+	19
3.	Methi roots	+	–	+	+	+	+	+	+	+	19
4.	Groundnut roots	+	+	+	+	+	+	+	+	+	19

+ = present – = absent

(*ii*) *Qualitative analysis of amino acids* :

The mycelia of 4 isolates giving high percentage protein content were analysed for the presence of various amino acids. The results given in Table 2 indicated the presence of all the essential amino acids. Histidine which is considered essential for children was absent in isolate No. 3. Threonine was absent in isolate No. 2.

The total number of amino acids recorded in isolate No. 1 were 21 while in other isolates only 19 amino acids were present.

(*iii*) *Protein production in different cellulosic materials* :

The isolate No. 1 which produced the highest protein was tested on other cheap cellulosic materials *viz*. Sugarcane bagasse, rice straw, and rice husk. Urea was used to give an equivalent amount of 600 mg N per litre for it was reported by Chahal and Gray (1969*a* and 1969*b*) that urea was the best source of N for *R. solani* for protein production.

The results presented in Table 3 indicate that protein production was highest on wood pulp as compared to the other cellulosic materials. The percentage of protein and total protein also increased with urea as compared to that obtained with potassium nitrate as N source. Rice husk gave the lowest amount of protein and proved to be the poorest source for protein production. The percentage of prot in was high in rice straw as compared to that of sugarcane bagasse, but total protein was lower than that of sugarcane bagasse. The low amount of total protein produced was due to the fact that weight of fungal mycelium and undigested materials was too low as compared to that obtained from sugarcane bagasse which showed that the fungus had degraded rice straw more to carbon dioxide rather than it utilised to build up fungal mycelium.

TABLE 3

Protein production by R. solani *on different cellulosic substrates*[1]

S. No.	Substrate	Final pH	Wt. of fungal mycelium and undigested substrate in mg after 4 days	Percentege of protein	Total protein per flask in mg
1.	Wood pulp	6·1	488	23·2	113
2.	Sugarcane bagasse	6·1	633	6·91	43
3.	Rice straw	6·4	389	8·75	34
4.	Rice husk	6·3	669	4·07	27

1. Original protein content :
   - Wood pulp = 1·56%
   - Sugarcane bagasse = 1·18%
   - Rice straw = 1·89%
   - **Rice husk = 3·15%**

Discussion

R. solani was reported as the best cellulolytic fungus which produced high amount of protein on wood pulp (Chahal and Gray, 1969*b*). Ten isolate of *R. solani* from various substrates were studied which differed to a great extent in respect of protein production. The isolate No. 1 from the roots of turnip gave the highest percentage and total protein production as compared to all the other isolates. The amino acids analysis of this isolate indicated the presence of 21 amino acids including all the essential ones.

The results indicated that cellulose (wood pulp) when free from lignin and other non-cellulosic material was better substrate for protein production than other cellulosic material like sugarcane bagasse, rice straw, and rice husk. The poorest growth was recorded on rice husk. Scheffer and Cowling (1966) while reviewing literature on microbial degradation of wood have concluded that lignin is most important non toxic factor which contribute to the natural resistance to the attack of cellulolytic wood destroying fungi. According to Yoshii (1936), Hashioka (1950), and Suzuki (1951) sillicic acid when deposited abundantly on ligno-cellulosic walls of epidermal cell increases resistance to fungus penetrations. Thus low protein production by *R. solani* on these substrate could be attributed to the presence of high content of lignin and silicon.

Summary

Synthesis of fungal protein by cellulolytic fungus, *Rhizoctonia solani*, when grown on cellulose, the cheapest and abundant source of organic carbon, has been exploited to alleviate the world protein deficiency. The qualitative analysis of amino acid content of the mycelium thus obtained indicated the presence of 21 amino acids. The different isolates of *R. solani* did not differ much qualitatively in respect of amino acids content but differed to a great extent in respect of total protein production. It was noticed that cellulose (wood pulp) when free from lignin and other non-cellulosic material was a better substrate for fungal protein production than other cellulosic materials used.

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The musculature of the head capsule and mouth parts of the Noctuid Larva, *Trichoplusia ni* Hubner

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Introduction

Practically all the workers who devoted themselves in distinguishing the head sclerites and sutures of the insects, have studied the cephalic musculature but there is a great diversity of opinion regarding these parts of the head capsule of a typical insect. Earlier works of Crampton (1921, 1928), Snodgrass (1928), DuPorte (1946) and Hinton (1948) covered all the important orders in which the head muscles have been described in detail. Cook (1944) explained the relationship of the labrum, clypeus and frons with each other and the head capsule on the origin and insertion of their muscles in a number of insects including *Pieris rapae* larva. Other notable works dealing with the mouth parts and cranial muscles of larval Lepidoptera are those of Short (1951), DuPorts (1956) and Eassa (1963). The present author has carefully compared the cranial muscles of the larval *Trichoplusia ni* Hubner with the corresponding muscles of other caterpillars and pointed out the differences.

Material and Methods

The larvae of *T. ni* were collected from the fields and reared in the laboratory on cauliflower leaves. Only mature larvae were used in the present study. After killing in hot water, larvae were preserved in formalin acetic acid alcohol mixture (Srivastava and Mathur, 1964). The head capsule was dissected in wax coated petridish in ninty percent alcohol. A bull's eye condenser was used to concentrate the rays of an electric light upon the object under study. Van Gleson's stain was used for distinguishing an individual muscle. Glycerine jelly mounts were prepared to study the origin and insertion of each muscle. The diagrams were drawn with the help of a camera lucida.

Description

The head capsule is spherical and about 2·0 mm wide. It is cephalocaudally compressed and the mouth parts are hypognathous. The sclerites are marked by prominent sutures and adorned by setae and punctures typical to the specific form.

The cephalic muscles of the larva are flat and long. The muscles are firmly attached at both the ends. The attachment of the stationary base is the origin and that of the movable part is the insertion. Some muscles are attached to the sclerotised cords or to integumentary invagination known as the apodeme.

I. The cranial muscles (Figs. 1, 2) originate from the cranium and support the anterior part of the alimentary canal. They are distinguished as follows :

(1) The cibarial muscles are composed of four stout pairs. The first pair originates from the clypeus (1), the second and third pairs (2, 3) are located in the central portion of the frons and the fourth pair (4) arises from the inner wall of the anterior tentorial arms (ATA).

(2) The prepharyngeal muscles also consist of four similar pairs of muscles. The first two pairs (5, 6) are closely situated on the anterior tentorial arms, the third pair (7) lies near the median line anterior to the fourth pair (8). The last one is located at the junction of the two frontal sutures.

(3) The anterior palatal muscles (9) originate slightly posteriorly to the third pair of prepharyngeal muscles. Anteriorly they are inserted on the palatum between the tormae (T) of the labrum (LM).

II. The muscles of the mouth parts are as follows :

(1) Labral muscles (Figs. 1, 2, 3). The muscles (10) originate from the deep folds of coronal suture. They cross the frons and clypeus, pass mesad to the cibarial muscles and are attached directly to the tormae.

(2) Mandibular muscles (Figs. 3, 4). The cranial abductor (11) and adductor (12) muscles are responsible for the movement of each mandible. The abductor muscles form a small group of fibres which originate from the genal area of the epicranium (EPI). The whole group inserts on the abductor apodeme (ABA). The adductor muscles occupy the major space in the craninm and are composed of a comparatively large number of fibres. These fibres are attached on the caudal end of the distally flattened adductor apodeme (ADA).

(3) Maxillo-labial muscles (Figs. 5, 6, 7, 8, 9). The component parts of the maxilla and labium are provided with the following muscles :

(*i*) Adductors of cardo. The adductors of cardo are distinguished into adductor one (13) and adductor two (14). Both the muscles are equal in length and taper at their insertion. They originate from the maxillary process of the tentorial arm (MTA). Adductor one is attached on the anterior angle of cardo while adductor two is inserted on the caudal side of cardo.

(*ii*) Adductors of stipes (15, 16). They originate from the maxillary process of the tentorial arm and insert almost in the middle of stipes.

(*iii*) Cranial flexors of inner lobe (17). They are flat and strip-like muscles which taper towards the insertion on the outer margin of inner lobe of the maxilla (LO). They originate from the hypostoma.

(*iv*) Cranial flexors of stipes (18). They originate from the genal angle of cranium and insert on the anterior side of stipes.

(*v*) Levators of maxillary palp (19). These are thick muscles which attach the cephalic wall of the palp (MXP), near the cranial flexor of inner lobe. They originate from the median basal part of stipes.

(*vi*) Depressors of maxillary palp (20). They also originate from the stipes adjacent to levator muscles. They divert from the latter and insert on the caudal side of the base of maxillary palp by means of short tendons.

(*vii*) Median muscles of prementum (21). They originate as thick bundles of muscle fibres from the tentorial bridge (TB). These fibres converge near the insertion and attach to the proximal border of the prementum (PRM).

(*viii*) Dorsal muscles of silk press (22). They are short, transverse and paired muscles which taper at the insertion. They originate on the dorso-lateral sides of prementum and insert on the sclerotic raphae of spinneret (SP).

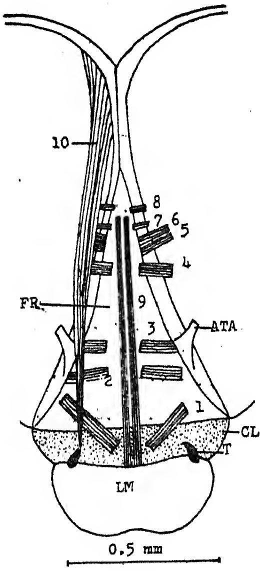
LIST OF FIGURES AND ABBREVIATIONS USED IN THE TEXT :

Muscles of the head capsule and mouth parts of larval *T. ni.*

Fig. 1. Facial region—internal view, Fig. 2. Lateral view of the cranial muscles in relation to gut, Fig. 3. Interior of the head from behind, Fig. 4. Mandibular muscles, Fig. 5. Muscles of maxilla and prementum, Fig. 6. Maxillary muscles—lateral view, Fig. 7. Maxillary muscles —dorsal view, Fig. 8. Labial muscles—ventral view, Fig. 9. Labial muscles—lateral view, Fig. 10. Antenna showing muscles.

ABA—Abductor apodeme, ADA—Adductor apodeme, AL—Accessory lobe, ANT—Antenna, ATA—Anterior tentorial arm, BR—Brain, CD—Cardo, CL—Clypeus, EC—Epicondyle, EPI—Epicranium, FGC—Frontal ganglionic connective, F—Flagellum, FR—Frons, HC—Hypocondyle, HP—Hypopharynx I—Incisors, LM—Labrum, LO—Inner lobe, LP—Labial palp, MD—Mandible, MN—Mentum, MR—Molar, MTA—Maxillary arm to tentorium MXP—Maxillary palp, OE—Oesophagus, P—Pedicel, PRM—Prementum, SC—Scape, SG—Silk gland, SM—Submentum, SP—Spinneret, ST—Stipes, STO—Stomodaeum, T—Tormae, TB—Tentorial bridge, TN—Tentorium, VD—Ventral dilators.

1 to 4—Cibarial muscles, 5 to 8—Prepharyngeal muscles, 9—Anterior palatal muscles, 10—Lateral labral muscles 11—Abductor muscles 12—Adductor muscles 13, 14—Adductors of cardo, 15, 16—Adductors of stipes, 17—Cranial flexor of inner lobe, 18—Cranial flexor of stipes, 19—Levator of maxillary palp, 20—Depressor of maxillary palp, 21—Median muscles of prementum, 22—Dorsal muscles of silk press, 23—Ventral muscles of silk press, 24—Dorso-hypopharyngeal muscles, 25—Ventral labial muscles, 26—Maxillary adductors, 27—Antennal flexor, 28. Antennal extensor.



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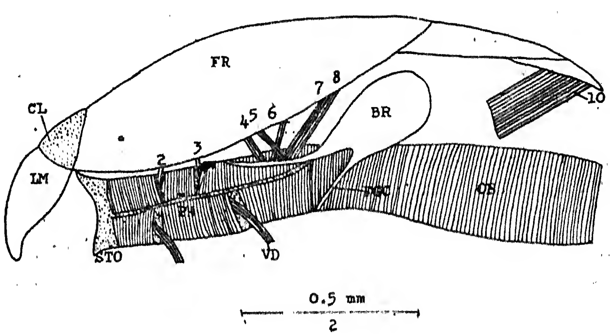

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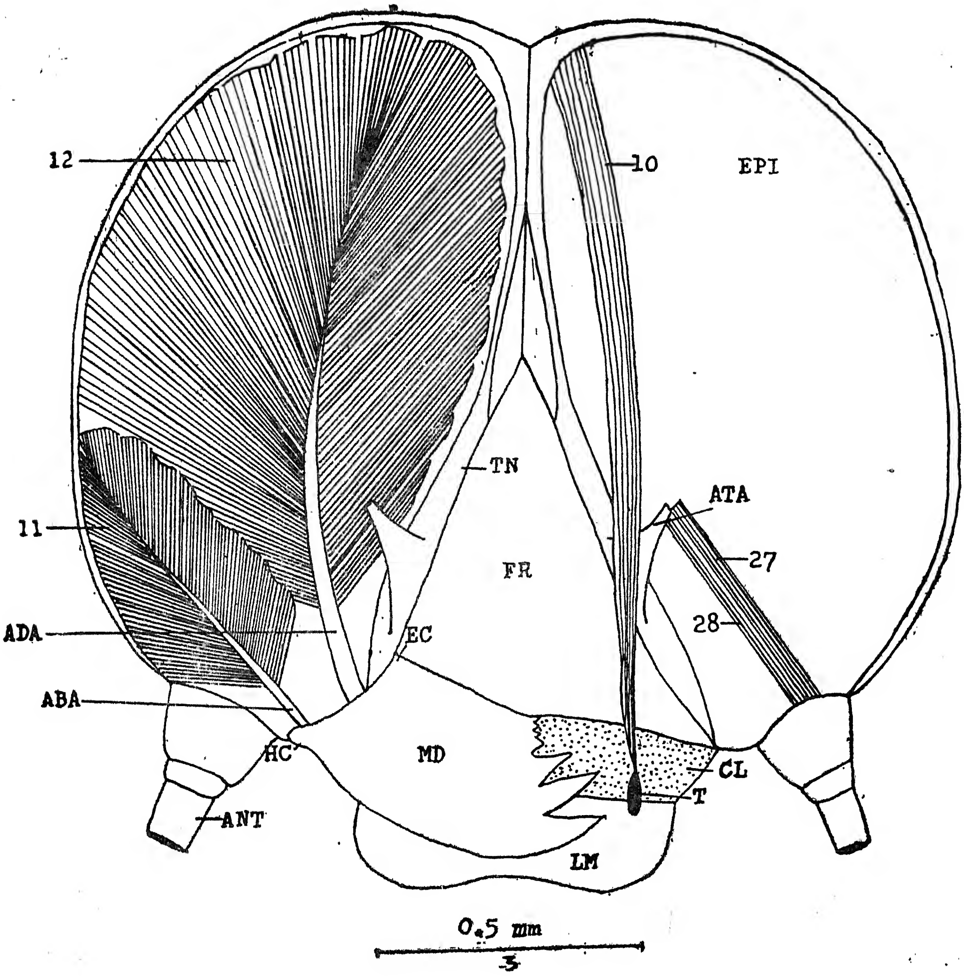
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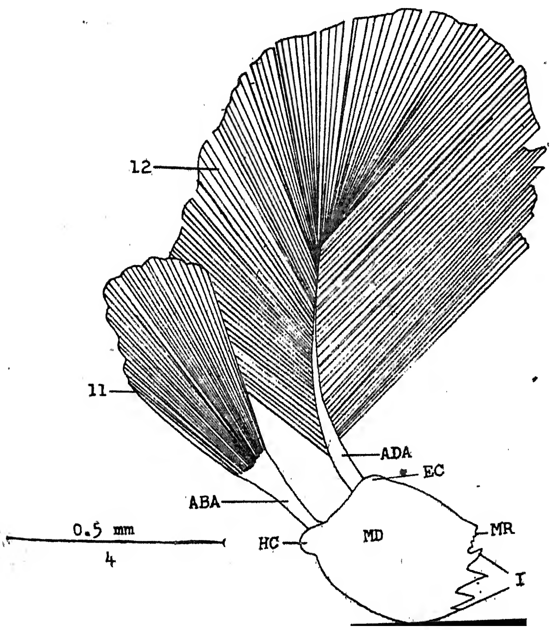
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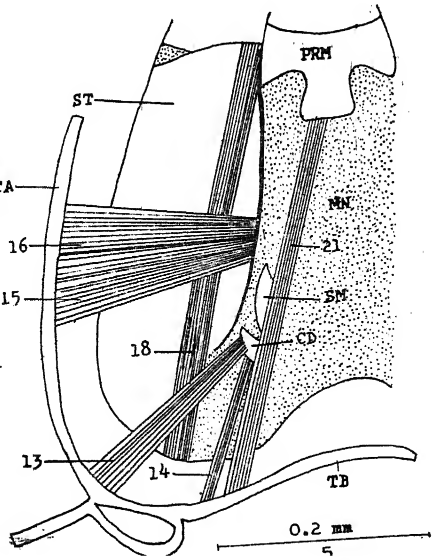
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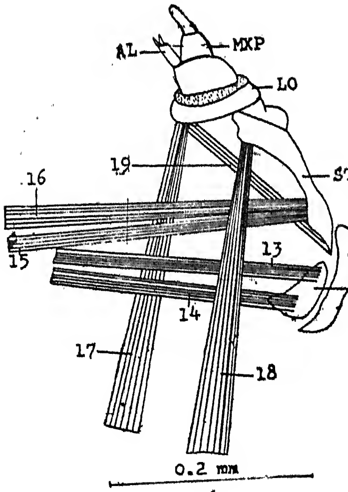

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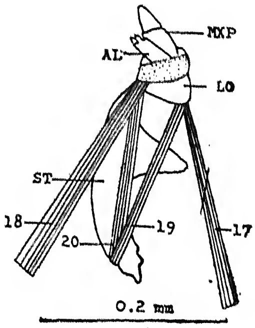

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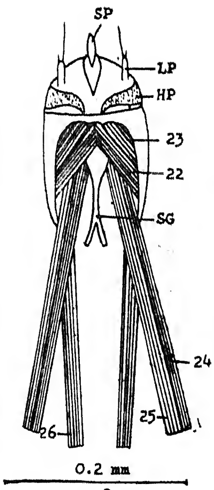

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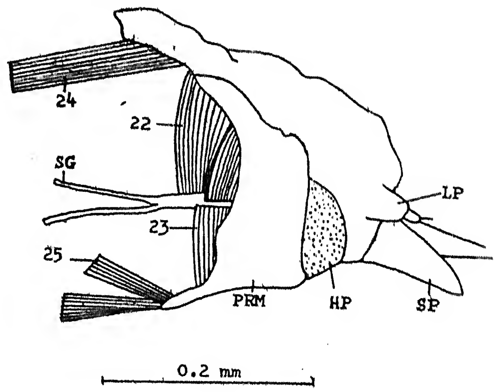

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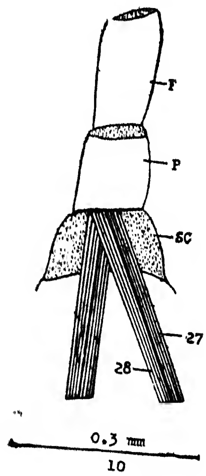

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(*ix*) Ventral muscles of silk press (23). They are thin, tubular and paired muscles. Each set has its origin on the ventral wall of the premental lobe. Both insert jointly on the lateral sides of the silk press.

(*x*) Dorso-hypopharyngeal muscle (24). They form two long muscles which originate from the tentorium. Each set has its insertion on the base of hypopharyngeal portion of the labium.

(*xi*) Ventral labial muscles (25). They arise from the tentorium and insert on the base of the prementum.

(*xii*) Maxillary adductors (26). These muscles arise from the tentorial brigde and insert on the fulcral arms of the hypopharynx (HP).

III. Muscles of the antenna (Figs. 3, 10). The whole antenna is moved by a set of muscles articulating with the basal segment, the scape (SC). These muscles are distinguished into antennal flexor (27) and antennal extensor (28). They originate in a single bundle from the drosal cranium and insert on the base of the scape.

Discussion

Snodgrass (1928) stated that the frontal and clypeal region can be identified with reference to their muscular attachments and this should be given priority in the correct identification of the sclerites. Accordingly, he recognised the so-called adfrontal area above the clypeal region on the basis of the attachment of the cibarial muscles. He also proposed that the frons may be recognised as the region which lies above the ridge of the median arm from where the pharyngeal muscles arise. DuPorte (1946) asserted that the origin of muscles can hardly be regarded as a suitable criterion since the muscles change their origin in course of time and new muscles arise and also some old ones atrophy to suit the need of the insects. Further, he designated the various areas simply with reference to their positions in respect of the labrum and made little attempt to study the muscular attachments. Consequently, he called the clypeal region of Snodgrass as antefrons and the membranous area between clypeus and labrum as the clypeus. Moreover, in his identification he modified the designation of the lateral or median arms of the epistomal suture as frontogenal sulcus and the transverse sulcus respectively. He further designated the suture between the clypeus and antefrons as the fronto-clypeal suture.

At this stage one is tempted to suggest that DuPorte's identification is based on configurational studies and entirely independent of the true musculature. It has been noted by Cook (1944) that the clypeus has reduced the area of the frons and the places of origin of the muscles arising from the frons shift to the more anterior sclerite, the clypeus. Thus in *Pieris* larva the clypeus is extended posteriorly, reducing the area of the frons which is merely represented by a narrow band. Such is not the case in larval *Trichoplusia ni*. Here the clypeus is much broader and the palatal muscles originate anteriorly to the terminal end of the coronal suture.

The abductor muscles of the mandibles comprise a large number of muscle fibres in *T. ni* as compared to *Pieris* (Eassa, 1963) which has only nine groups. The abductor muscles occupy most of the cranial cavity and bear similar muscles and apodemes as described by Snodgrass (1935), Das (1938), Eassa (1963) and Srivastava and Mathur (1964).

The antennae of *T. ni* show primitive condition in respect to the origin of muscles in the cranial wall. In this larva, there are two sets of muscles, each having two muscle fibres, whereas in *Pieris* there is only one antennal muscles on each side supplying to the respective antenna (Eassa, 1963).

Summary

Muscles of the head capsule, mouth parts, cibarium and antennae of the larval *Trichoplusia ni* Hubner together with their origin and insertion have been studied.

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